

# International Space Station Medical Operations

Jeffrey (Jeff) A. Jones, MD NASA/JSC Houston, TX

*Acknowledgements: Sean Roden, MD, Steven Hart, MD, Ed Powers, MD, Terry Taddeo, MD, J.D. Polk, DO, D. Hamilton, MD, and J. Michael Duncan, MD*

NASA is currently the leader, in conjunction with our Russian counterpart co-leads, of the Multilateral Medical Policy Board (MMPB), the Multilateral Medical Operations Panel (MMOP), which coordinates medical system support for International Space Station (ISS) crews, and the Multilateral Space Medicine Board (MSMB), which medically certifies all crewmembers for space flight on-board the ISS. These three organizations have representatives from NASA, RSA-IMBP (Russian Space Agency-Institute for Biomedical Problems), GCTC (Gagarin Cosmonaut Training Center), ESA (European Space Agency), JAXA (Japanese Space Agency), and CSA (Canadian Space Agency). The policy and strategic coordination of ISS medical operations occurs at this level, and includes interactions with MMOP working groups in Radiation Health, Countermeasures, Extra Vehicular Activity (EVA), Informatics, Environmental Health, Behavioral Health and Performance, Nutrition, Clinical Medicine, Standards, Post-flight Activities and Rehabilitation, and Training.

Each ISS Expedition has a lead Crew Surgeon from NASA and a Russian Crew Surgeon from GCTC assigned to the mission. Day-to-day issues are worked real-time by the flight surgeons and biomedical engineers (also called the Integrated Medical Group) on consoles at the MCC (Mission Control Center) in Houston and the TsUP (Center for Flight Control) in Moscow/Korolev. In the future, this may also include mission control centers in Europe and Japan, when their modules are added onto the ISS. Private medical conferences (PMCs) are conducted regularly and upon crew request with the ISS crew via private audio and video communication links from the biomedical MPSR (multipurpose support room) at MCC Houston. When issues arise in the day-to-day medical support of ISS crews, they are discussed and resolved at the SMOT (space medical operations team) meetings, which occur weekly among the International Partners. Any medical or life science issue that is not resolved at the SMOT can be taken to the Mission Management Team meeting, which occurs biweekly from MCC-Houston. This meeting includes the other International Partners and all flight support and console position representatives via teleconference. ISS Crew Surgeons have handled many medical conditions on orbit; including skin rashes, dental abscesses, lacerations, and ST-T segment EKG changes. Fortunately to date, there have not been any forced medical evacuations from the ISS. This speaks well for the implementation of the primary, secondary and even tertiary prevention strategies invoked by the Integrated Medical Group, as there were several medical evacuations during the previous Russian space stations.

Assignment for ISS Expedition surgeons usually occur at the same time as the astronaut crew assignment, which is typically 18-24 months prior to the flight. Training for the Crew Surgeon requires 204 hours of classes, 100 hours of on the job training and qualifications, and over 100 hours of console simulation and real-time mission support.

This involves complete knowledge of both U.S. and Russian medical systems. The Crew Surgeon also participates in the training of his crew in medical operations hardware and procedures. The Crew Surgeon supports any hazardous training of the Expeditionary crew, which includes winter and water survival, vacuum chamber training, and neutral buoyancy EVA training. ISS Expeditions vary in duration from 4- 7 months. The crew is then rehabilitated for 45 days after flight, under Crew Surgeon supervision. So the time commitment for an Expedition assigned ISS Crew Surgeon is quite long, usually 25-33 months.

Launch and landing of ISS crews can be from KSC (Kennedy Space Center), Florida or Baikonour in Kazhakstan. The Crew Surgeon and Deputy Crew Surgeon travel to the launch and landing site several days prior to the anticipated event to provide support for expected medical issues and for any launch and landing contingencies.



U.S. and Russian flight surgeons after the STS-111/Expedition 5 launch to ISS

Surgeons support EVAs from either the MCC in Houston, or the TsUP in Moscow, depending upon whether the EVA is conducted in the U.S. spacesuit (Extravehicular Mobility Unit or EMU) or in the Russian Orlan (“eagle” in Russian) spacesuit. The Russians name their suits after birds, as also seen by their launch and entry suit, which is named Sokol (falcon) and their loading suit, which is named Pengvin (penguin).



Flight surgeons support an ISS-based EVA from the Blue Flight Control Room at MCC-Houston

There are numerous differences between the U.S. and Russian medical approaches to supporting long duration spaceflight, but the number and magnitude of those differences has lessened with the experience of the ISS, especially in the area of exercise countermeasures. There have been compromises from both sides in developing an integrated medical support program, and in many ways the MMOP has led the way among the ISS support teams in establishing a multilateral implementation plan built by consensus. Still there are unresolved differences between the U.S. and Russian space medical philosophies. For example, the Russians continue to employ thigh cuffs (“brazelets”) to reduce the headward fluid shift during initial entry into microgravity, they require the crew to wear the “Penguin” bungee-loading suits while on orbit to offer resistance to the muscles, and they use LBNP (Lower Body Negative Pressure) as a countermeasure prior to re-entry. The Russians also use a number of herbal or alternative medical prophylactic agents for reducing the physiological re-adaptation effects from microgravity to 1-g. Few, if any, of these countermeasures are utilized at present by NASA. The Russian onboard diagnostic and medical hardware varies in many ways from the U.S. hardware, although both are now used in an integrated fashion. For example, the Russian ECG hardware can only be active with live downlink while the vehicle is passing over Russian ground stations, while the U.S. hardware allows storage and forwarding at anytime in the orbit where Ku-band antenna coverage is available. The Russian  $\gamma$ -medical hardware system allows for chemical serum analysis, but only one analyte at a time, while the U.S. employs a PCBA (Portable Clinical Blood Analyzer) which provides a panel of analytes to be run concurrently from a single drop of blood.



Advanced Life Support Pack; Respiratory Support Pack, and Crew Medical Restraint System for ISS

As with any multinational effort, politics plays a large role in the daily lives of the MCC flight controllers, especially in regards to financial matters. The term “balance of contributions” is now well known to all the International Partners and is used at ISS strategic planning meetings to determine prioritization of everything from the flight manifest to crew scheduling of flight activities. Even though English is the official language on the ISS, the Russian segment equipment labels are chiefly in Russian, and the crews speak “Ruglish”, a hybridization of English and Russian, depending on which segment of the vehicle they are currently residing in. Some language barriers still do exist, but not nearly as extensively as during the early NASA Phase 1 Program on-board the Mir. Now all transmissions from either MCC to the ISS and back are interpreted real-time and can be monitored on one of the audio loops in the MCC. There are interpreters readily available to allow reliable communication between the MCC and TsUP anytime on Orbits 1 and 2 (day and evening shift, until the crew sleeps). Politics often play significant roles in ISS activities, such as crew selection, system training, and flight

hardware certification, and will probably eventually be thoroughly discussed in the autobiography of existing or prior ISS program managers. No doubt that it will be interesting reading!

The ISS medical operations organization is committed to the health and safety of the crews who fly onboard the space station; and have developed a medical support system which allows high medical standards (primary), medical countermeasures (secondary), and on-board medical care (tertiary) prevention practices to be applied, in the great tradition of Aerospace Medicine.

In closing, it is safe to say that working with our International Partners on the ISS has been exceedingly challenging from a professional and operational standpoint. At the same time, it has been very rewarding to know that we have been participants in the world's largest engineering project ever attempted. It is also very gratifying to see a group of nations, all of which have been at war with each other over the past century, now working together in mutual cooperation and synergism towards a peaceful and scientifically enriching endeavor. In a world filled with international strife and violence, it is refreshing to have the opportunity to build something greater than our individual selves, to the benefit of all humankind.